-NUTRIOSO CREEK TMDL- FOR TURBIDITY

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TABLE OF CONTENTS

SECTION *PAGE NUMBER*

Executive Summary

Section 303(d) of the Clean Water Act requires that States develop Total Maximum Daily Loads (TMDLs) for surface waters that do not meet and maintain applicable water quality standards. A TMDL sets the amount of a given pollutant that the waterbody can withstand without creating an impairment of that surface waters designated use. The TMDL by definition (40 CFR Part 130) is the sum of all Waste Load Allocations (point source) and Load Allocations (non-point source) with the inclusion of a margin of safety and natural background conditions.

Nutrioso Creek is located in the White Mountains near Springerville, AZ. Nutrioso Creek was listed as an impaired water for violating the turbidity standard for aquatic and wildlife cold water streams, which is currently set at 10 Nephelometric Turbidity Units (NTU.) The samples used to list the stream were collected from 1993-1996. The entire reach of Nutrioso Creek was listed in the 303(d) list, from the headwaters to the confluence with Picnic Creek, a 27 mile section, and from the Picnic Creek confluence to the confluence with the Little Colorado River, a 3.7 mile section.

Nutrioso Creek was the subject of an intensive turbidity study in November of 1999 and January of 2000. The results of this study indicate that the majority of the stream meets turbidity standards. A portion of the stream from the town of Nutrioso to Nelson Reservoir, about 7 miles, still violates the 10 NTU standard (primarily concentrated in a 3 mile section.) Field investigations indicate that entrenchment due to historic cattle grazing is a primary factor causing increased turbidity levels. The historic and current grazing practices also caused a loss of riparian vegetation, such as willows, which would help stabilize banks, dissipate stream energy, and slow stream velocities. The entrenchment of the stream caused a loss of flood plain, which led to increased stream velocity and shear stress at higher flows. The soils are primarily composed of a silty -organic clay and are highly susceptible to freeze-thaw and wind erosion in addition to water borne erosion.[20]

The Target Load Capacity for Nutrioso Creek during critical spring flows was calculated to be 183 lbs/day as Total Suspended Solids (TSS.) The Measured Load was estimated to be 1020 lbs/day as TSS. The TMDL for Turbidity (as TSS) for critical spring flow conditions is 183 lbs/day. The Load Reduction necessary is 837 lbs/day of TSS. During the average base flow conditions no Load Reduction is necessary, as there is no violation, there is an estimated 9.1 lbs/day (TSS) gap between the Measured Load (10.7 lbs/day) and the Target Load (19.8 lbs/day.)

The Turbidity impairment appears to be directly correlated to the increased flows in the critical spring flow event. Implementation projects and best management practices will focus on reducing stream water velocities during these higher flows by increasing riparian vegetation, stabilizing banks, promoting the development of a flood plain, minimizing the impact of cattle and elk, and decreasing the contributions to the sediment loads to Nutrioso Creek due to sheet flow and wind erosion. Continued monitoring and milestones will be used to evaluate the success of individual best management practices and to reevaluate goals and strategies for achievement of water quality standards during critical flow periods.

BACKGROUND INFORMATION

GEOGRAPHY

Nutrioso Creek is located in the Little Colorado River Basin in southern Apache County along the eastern border of Arizona and is about a 30 mile long tributary to the Little Colorado River. The headwaters originate on Escudilla Mountain (elevation 10,912 ft.) and flow approximately twenty-three miles north and then turn west to flow into Round Valley east of Springerville, AZ.[21] The stream continues for an additional seven miles to the west to its' confluence with the Little Colorado River at an elevation of 6907 ft.[21] (see Map 1)

HYDROLOGY

The Nutrioso Creek watershed drains approximately 159 square miles with an overall drop in elevation of 1500 ft (8400 ft to 6900 ft.)[21] Nutrioso Creek is a 5th order stream as identified using a USGS topographic map.[21] Nutrioso Creek responds primarily to a spring snowmelt and rain season from mid February to the beginning of May. Nelson Reservoir, located thirteen miles downstream of the headwaters, captures the snowmelt. Nelson Reservoir has a surface area of approximately 60 acres and releases a portion of the snowmelt, over a spillway, back into the Nutrioso Creek stream course. Two United States Geological Survey (USGS) gauge stations are present on Nutrioso Creek, neither of which has operated since 1989.(14) One is located just upstream of Nelson Reservoir (USGS station # 09383500), while the second is just downstream of Nelson Reservoir (USGS station # 09383550.) The major tributaries to Nutrioso Creek are Auger Creek, Colter Creek, Riggs Creek, Milk Creek, Rudd Creek, Hulsey Creek, Paddy Creek, and Picnic Creek. In general, the small mountain stream portions are steep and store little sediment, while the intermediate valley floor portions of the stream possess low gradients and high sinuosity and are overladen with sediment.(18)

LAND USE

According to the land ownership information provided by Arizona Land Resource Information System (ALRIS), most of the Nutrioso Creek watershed is a mixture of Federal and State lands and private land (see Map 1.) Land ownership is comprised of 48.6% private party ownership, 45.2% USFS Apache-Sitgreaves National Forest lands, 3.5% Arizona State Trust lands, and 2.7% Arizona Game and Fish lands. The majority of the headwaters are USFS land compromising part of the Apache-Sitgreaves National Forest.(35) The major land use in the area for private lands is agricultural activities, primarily cattle grazing.

VEGETATION

The vegetation of the Nutrioso Creek watershed can be divided into an uplands portion and a valley portion. The uplands area, located from just north of the town of Nutrioso to the headwaters in the Apache-Sitgreaves National Forest, at elevations above approximately 8000 ft, is comprised of ponderosa pines and mixed conifers with some spruce fir in the higher elevations.(35) The Nutrioso Creek valley extends from the town of Nutrioso to the confluence with the Little Colorado River and is comprised primarily of grasses, small shrubs, and some willows interspersed with some pinon pine and juniper.(35)

ENDPOINT IDENTIFICATION

TURBIDITY, AND THE LINKAGE OF WATER QUALITY AND POLLUTANT STANDARDS

According to the US EPA, the recommended approach to the development of TMDLs, Waste Load Allocations, and Load Allocations, with limited data, is to develop estimates comprising of the best methods and data available.(32) Turbidity is a measure of the refraction of light as it passes through a sample of water, which is caused by the scattering of the photons. This scattering can be due to a variety of causes, however the turbidity standard was created as an indirect measure to protect aquatic wildlife uses from excessive sedimentation and excessive algal blooms. Because turbidity is a dimensionless unit, it is not easily transferred into the TMDL framework. As a result, a quantitative relationship was developed linking turbidity values to TSS values (see Graph 2.) Target Load Reductions of TSS will equate to reductions of turbidity in order to meet the turbidity water quality standard. For this TMDL a local TSS versus Turbidity correlation was created (see Graph 2.) This allows for the correlation of TSS values in mg/L to turbidity standards and measurements. This is useful as the increased turbidity during high flows is caused by higher TSS due to increased stream water velocities, shear stress, and stream power -which all result in higher erosional forces.

BACKGROUND SITE LOCATION AND VALUES

After searching the nearby areas for a suitable match to the geography, geology, hydrology, and channel morphology of Nutrioso Creek with minor anthropogenic influences, it was determined that most of the surrounding area has experienced the same channel degradation (and was therefore unsuitable for a background location) or did not match the same slope, sinuosity, vegetation, and geology of Nutrioso Creek. The background site was therefore located approximately 4.6 stream miles downstream of Nelson Reservoir in a small valley away from the highway and in an area that appears to be relatively undisturbed by ongoing cattle grazing and human impacts.(35) Nelson Reservoir acts as a sediment trap, decreasing stream velocity and allowing suspended solids to settle out prior to reaching this site location. While this background site is downstream of a reservoir and is thus affected to some degree by hydromodification, stream channel characteristics better resemble those characteristics considered representative of the desired future condition of Nutrioso Creek upstream of the reservoir following implementation Best Management Practices (BMPs.)

The background site has matching sinuosity, gradient, and geology to the main portion of Nutrioso Creek in the valley. The vegetation at the background site consists of willows in the stream course and on the point bars. Small shrubs and grasses comprise the vegetation surrounding the stream course. The stream itself has eroded banks formed as cutbanks and established point bars, which is to be expected given the silty-organic clay make-up of the soils in the region. The stream at the background location has a mixture of riffles, runs, and pools. The Flow at the background site, as measured upon site visits, matches the average base flow for Nutrioso Creek from USGS records (Graph 1.)(14) The average of the turbidity values measured during site visits was used to calculate the background turbidity and corresponding TSS values in this analysis.

IDENTIFICATION AND DESCRIPTION OF POLLUTANT SOURCES

In order to verify and identify a turbidity impairment on Nutrioso Creek a watershed wide sampling effort was undertaken in November of 1999. One hundred and twelve turbidity readings were obtained at 32 sampling stations over a three day period using a Hach brand turbidity meter. The turbidity values for each station were averaged and then plotted over a USGS topographic map cover using ArcView Geographic Informational Systems (GIS) (see Map 2.) Other more specialized sampling efforts were conducted in January 2000 and March 2000 to further identify and describe the turbidity and its sources and values and the condition of the stream itself.

In the 1998 303(d) list, Nutrioso Creek is listed as impaired by turbidity from the headwaters all the way to the confluence with Picnic Creek, and from Picnic Creek to the confluence of the Little Colorado River.(5) The November 1999 sampling effort defined the area of observed impairment to be approximately seven stream miles long occurring from slightly below the Town of Nutrioso to Nelson Reservoir, with the primary area of exceedences occurring in the middle portion of about three miles. There are three primary landowners within this three mile portion of stream. No discernable point sources of turbidity were located. All of the loading is due to non-point source impacts on the area. This three mile central portion is where historic overgrazing occurred in conjunction with poor range management strategies. Grazing in the area dates back to the late 1800s (13).

Portions of the Nutrioso Valley experienced heavy grazing since the late 1800s.(13) The highest measured turbidity values occur in an area where one of the current landowners has actively undertaken efforts to implement improved grazing practices. The property in question was purchased by the current landowner in 1996 and renamed the EC Bar Ranch. He has changed range management practices and has been actively seeking grant monies to protect the riparian corridor, help restore the stream, and implement more Best Management Practices.(13) He has been awarded grant money by the Arizona Water Protection Fund (AWPF) and ADEQ 319 grant money.(13) He has entered into a Cooperative Stewardship Agreement with AGFD and has received matching funding though the Environmental Quality Incentive Program (EQIP) and Stewardship Incentive Program (SIP.)(13) The NRCS has developed a conservation plan and provides on-going assistance.(13) The other two adjacent landowners, within the three mile section of particular concern, are currently seeking funding to implement BMPs and improved range management strategies on their lands.

There has been about a 75% reduction in cattle numbers in the Nutrioso Creek area since 1993.(13) In addition there has also been a 45% decrease in the number of elk in the watershed from 1993 to 1998.(6) Also the E.C. Bar Ranch (located within the 3 mile section of stream with higher turbidity readings) was the subject of a study by Wight Consulting to determine the Bureau of Land Management (BLM) Proper Functioning Condition (PFC) score. In 1996 it was found to be “Functional-at-risk with a downward trend.” In 1999, after implementation of some best management practices, the same area was found to be “Functional-at-risk with an upward trend.”(37)

WASTE LOAD ALLOCATIONS

The entire stream segment, from the town of Nutrioso to the USGS gauge station above Nelson Reservoir, was surveyed, and measurements and notes were taken as to the stream and channel morphology to identify areas of severe erosion and sediment loading. No point sources of turbidity were found to be present on Nutrioso creek for turbidity. Therefore, the Waste Load Allocation for all TMDL calculations is zero.

LOAD ALLOCATIONS

The turbidity impairment in Nutrioso Creek is a result of suspended solids in the form of excessive sediment. The excess sediment is coming from the banks of the stream itself, which is incised in areas due to channel degradation.

This downcutting of the channel created a loss in flood plain for the stream. A loss of flood plain in the channel means that during high flows, like the critical spring flows, the stream velocities are increased, thus increasing the shear stress/force acting upon the stream banks and thus increasing the erosional forces.

This portion of Nutrioso Creek also suffers from a lack of adequate riparian vegetation. The absence of willows in the stream course contributes to higher velocities during high flows, as they are not present to dissipate stream energy and act as a sediment trap holding soils in place.[30] In the rangeland itself, populations of Rubber Rabbitbrush (*Chrysothamnus nauseosus*) have driven off much of the native grasses. The Rabbitbrush occupies a large surface area, however the roots are only under the central portion of the bush. Native grasses provide a thicker root matte and do a better job holding soils in place and preventing excessive wind and sheet flow erosion.[31]

Field measurements and observations support the following conclusions regarding sources of sediment loading (in relative order of significance):

1. Stream bank degradation/erosion within the stream channel
2. Freeze-thaw erosion of the stream banks caused by the capillary action of the silty-organic clay soils which comprise the region coupled with the change in temperatures[20]
3. Sheet flow erosion of the surrounding landscape that is washed into the stream channel
4. Wind and airborne erosion from the very strong valley winds blowing the fine soil particles into the stream channel
5. Sediment transport from the headwaters

CONSIDERATION OF SEASONAL VARIATION

The discharge values for the USGS gauge stations, located above and below Nelson Reservoir on Nutrioso Creek, were averaged for each month from 1968-1989.[14] These values were then plotted in Graph 1, Appendix. The large seasonal variation in flow in Nutrioso Creek is due primarily to snowmelt run-off and some spring rain events. The high runoff period occurs from mid February to the beginning of May.

To take into consideration this seasonal variation, the critical flow condition is calculated to be the average flow value during the spring flow event. Average monthly flow values for this period (February, March, April, and May) were summed and divided by four to obtain an average critical flow value. The Average Spring Critical Flow value was calculated to be 4.3 cfs. The average critical flow value was then used to calculate a corresponding turbidity and TSS reading by utilizing the Turbidity & TSS vs. Discharge graph (Graph 3, Appendix) and the TSS vs. Turbidity graph (Graph 2, Appendix). Both of the correlation graphs, and the resulting equations, are based on data obtained through field measurements on Nutrioso Creek. This correlation allows a numeric estimate of the amount of sediment and turbidity present in the stream during critical flow. The average stream flow for the remaining 8 months was calculated and found to be considerably lower, 0.46 cfs as opposed to 4.3 cfs.[14]

MARGIN OF SAFETY

The Margin of Safety (MOS) for this TMDL is set to be 15% of the Load Allocation value. This MOS accounts for errors in using the average flows for seasonal variation, the innate errors present in the correlation of TSS with turbidity and discharge, and for the accuracy of the measurements and instruments.

TMDL CALCULATION

Calculations for the TMDL for turbidity for the critical spring flow is as follows:

The following equations were derived from values obtained from field measurements and data collection, and have strong statistical correlation values. These equations are used throughout the subsequent data calculations.

Equation 1. Taken from the solution to the line best fitting the data in Graph 2, TSS vs. Turbidity (Appendix)

$$TSS = 0.7914\,(\text{turbidity})$$

Equation 2. Taken from the solution to the line best fitting the data in Graph 3, TSS and Turbidity vs. Discharge (Appendix)

$$Turbidity = 13.028\,(\text{discharge}) - 0.5785$$

CRITICAL SPRING FLOW VALUES

Equation 3. CALCULATION OF BACKGROUND VALUE (lbs. of TSS per day)

Flow (mgd) x average ***TSS*** (mg./L) x 8.34@ ***= Background, TSS*** (lbs./day)

NUTRIOSO CREEK: CALCULATION OF BACKGROUND VALUE				
Flow (cfs)	***Flow (mgd)***	Turbidity (NTU)	***TSS (mg/L)***	***Background, TSS (lbs./day)***
0.42+	0.271	2.87*	2.27#	**5.1**

@ - 8.34 is a conversion factor to transform mg./L to lbs./day, the units are (lbs.)(L)/(mg)(10^6 gallons)
+ - Average flow values taken upon site visits to Background site location (close correlation to calculated base flow value of 0.46 cfs)
* - Average of Turbidity readings taken upon the site visits to the background location in 1999 -2000
# – Calculated using Equation 1 from Graph 2, TSS vs. Turbidity (in the Appendix), and inputting the turbidity value of 2.87 NTU

Equation 4. CALCULATION OF TARGET LOAD CAPACITY (LBS. OF TSS PER DAY)

Flow (mgd) x ***TSS target*** (mg./L) x 8.34@ = ***Target Load*** Capacity, TSS (lbs./day)

NUTRIOSO CREEK: CALCULATION OF TARGET LOAD FOR CRITICAL SPRING FLOW				
Flow (cfs)	***Flow (mgd)***	Turbidity Std. (NTU)	***TSS target (mg/L)***	***Target Load, TSS (lbs./day)***
4.3+	2.78	10.0*	7.91#	**183**

@ - 8.34 is a conversion factor to transform mg./L to lbs./day, the units are (lbs.)(L)/(mg)(10^6 gallons)
+ - Average flow values during critical spring flows as identified in graph 1 (in the Appendix) averaged over the 4 month period
* - Arizona Aquatic and Wildlife cold-water stream surface water quality standard for turbidity is 10 NTU
# – Calculated using Equation 1 from Graph 2, TSS vs. Turbidity (in the Appendix), and inputting the turbidity value of 10 NTU

Equation 5. CALCULATION OF NUTRIOSO CREEK TMDL FOR CRITICAL SPRING FLOW

TMDL as TSS (lbs./day) = WLA + LA + BG + MOS

MOS + LA = TMDL – WLA –BG but, *MOS = .15(LA)*

.15(LA) + 1(LA) = TMDL – WLA –BG

LA = (TMDL – WLA – BG)*/(1.15)*

NUTRIOSO CREEK: CALCULATION OF TMDL FOR CRITICAL SPRING FLOW				
WLA (lbs./day)	***LA (lbs./day)***	***Background (lbs./day)***	MOS, 15% (lbs./day)	***TMDL (lbs./day)***
0	**154.8**	5	23.2+	**183**

+ - Margin of Safety is 15% of the Load Allocation to accommodate for errors in data, graphical interpretations, and calculations of values

Equation 6. CALCULATION OF THE MEASURED** LOAD FOR CRITICAL SPRING FLOW

Flow (mgd) x ***Measured** TSS*** (mg./L) x 8.34@ = ***Measured** Load, TSS*** (lbs./day)

NUTRIOSO CREEK: CALCULATION OF MEASURED** LOADS FOR CRITICAL SPRING FLOW				
Flow (cfs)	***Flow (mgd)***	Measured** Turbidity (NTU)	***Measured** TSS (mg/L)***	***Measured** Load, TSS (lbs./day)***
4.3+	2.78	55*	44#	**1020**

** - The term "Measured" refers to values which were estimated using the correlation graphs, and are not representative of actual field measurements at this flow regime, due to poor runoff this season
@ - 8.34 is a conversion factor to transform mg./L to lbs./day, the units are (lbs.)(L)/(mg)(10^6 gallons)
+ - Average flow values during critical spring flows as identified in graph 1 (in the Appendix averaged over the 4 month period
* - Calculated using Equation 2 from Graph 3, Turbidity & TSS vs. Discharge (in the Appendix), and inputting the avg. flow of 4.3 cfs
#– Calculated using Equation 1 from Graph 2, TSS vs. Turbidity (in the Appendix), and inputting the turbidity value 55 NTU

Equation 7. CALCULATION OF TSS LOAD REDUCTION (LBS. PER DAY)

Measured** Load - Target Load = ***Load Reduction, TSS*** (lbs./day)

NUTRIOSO CREEK: CALCULATION OF LOAD REDUCTIONS FOR CRITICAL SPRING FLOW		
Measured** Load, TSS (lbs./day)	***Target Load, TSS (lbs./day)***	***Load Reduction, TSS (lbs./day)***
1020	183	**837**

** - The term "Measured" refers to values which were estimated using the correlation graphs, and are not representative of actual field measurements at this flow regime, due to poor runoff this season

AVERAGE BASE FLOW VALUES

Those TMDL calculations were based upon the critical spring average flow value of 4.3 cfs during that four month period, from (and including) February to May. However, recalculation of the various TMDL values using the average base flow value of 0.46 cfs over the remaining eight month period reveals some interesting information about the watershed during non-critical flows.

Equation 4. CALCULATION OF TARGET TSS LOAD, ADJUSTED FOR NON-CRITICAL FLOW (BASE FLOW)

Flow (mgd) x ***TSS target*** (mg./L) x 8.34@ = ***Target Load*** Capacity, TSS (lbs./day)

NUTRIOSO CREEK: CALCULATION OF TARGET LOAD FOR AVERAGE BASE FLOW				
Flow (cfs)	***Flow (mgd)***	Turbidity Std. (NTU)	***TSS target (mg/L)***	***Target Load, TSS (lbs./day)***
0.46+	0.300	10.0*	7.91#	**19.8**

@ - 8.34 is a conversion factor to transform mg./L to lbs./day, the units are (lbs.)(L)/(mg)(10^6 gallons)
+ - Average flow values during base flows as identified in graph 1 (in the Appendix) averaged over the 8 month period
* - Arizona Aquatic and Wildlife cold-water stream surface water quality standard for turbidity is 10 NTU
# – Calculated using Equation 1 from Graph 2, TSS vs. Turbidity (in the Appendix), and inputting the turbidity value of 10 NTU

Equation 5. CALCULATION OF TMDL DURING BASE FLOW CONDITIONS

TMDL as TSS (lbs./day) = WLA + LA + BG + MOS

MOS + LA = TMDL – WLA –BG *but, MOS = .15LA)*

.15(LA) + 1(LA) = TMDL – WLA –BG

LA = (***TMDL – WLA – BG***)/(1.15)

NUTRIOSO CREEK: CALCULATION OF TMDL FOR AVERAGE BASE FLOW				
WLA (lbs./day)	***LA (lbs./day)***	***Background (lbs./day)***	MOS, 15% (lbs./day)	***TMDL (lbs./day)***
0	**12.9**	5	1.9+	**19.8**

+ - Margin of Safety is 15% of the Load Allocation to accommodate for errors in data and graphical interpretations and calculations of values

Equation 6. CALCULATION OF THE MEASURED** LOAD FOR BASE FLOW CONDITIONS

Flow (mgd) x ***Measured** TSS*** (mg./L) x 8.34@ = ***Measured** Load, TSS*** (lbs./day)

NUTRIOSO CREEK: CALCULATION OF MEASURED** LOADS FOR AVERAGE BASE FLOW				
Flow (cfs)	***Flow (mgd)***	Measured** Turbidity (NTU)	***Measured** TSS (mg/L)***	***Measured** Load, TSS (lbs./day)***
0.46+	0.300	5.41*	4.28#	**10.7**

** - The term "Measured" refers to values which were estimated using the correlation graphs, and are not representative of actual field measurements at this flow regime, due to poor runoff this season
@ - 8.34 is a conversion factor to transform mg./L to lbs./day, the units are (lbs.)(L)/(mg)(10^6 gallons)
+ - Average flow values during base flows as identified in graph 1 (in the Appendix) averaged over the 8 month period
* - Calculated using Equation 2 from Graph 3, Turbidity & TSS vs. Discharge (in the Appendix), and inputting the average flow of 0.46 cfs
# – Calculated using Equation 1 from Graph 2, TSS vs. Turbidity (in the Appendix), and inputting the turbidity value 5.41 NTU

Equation 7. CALCULATION OF LOAD REDUCTIONS FOR BASE FLOW CONDITIONS

Measured** Load - Target Load = ***Load Reduction***, TSS (lbs./day)

NUTRIOSO CREEK: CALCULATION OF LOAD REDUCTIONS FOR AVERAGE BASE FLOW		
Measured** Load, TSS (lbs./day)	***Target Load, TSS (lbs./day)***	***Load Reduction, TSS (lbs./day)***
10.7	19.8	**None** (under Target by 9.1)

** - The term "Measured" refers to values which were estimated using the correlation graphs, and are not representative of actual field measurements at this flow regime, due to poor runoff this season

Comparison of critical flow values versus the average base flow values indicates that excessive suspended solids and violation of the TMDL for turbidity on Nutrioso Creek occurs during high spring flows. This TMDL and the implementation strategies are thus focused towards decreasing erosion, sediment transport, and excessive turbidity during the spring critical flow regime.

IMPLEMENTATION

BEST MANAGEMENT PRACTICES

A variety of Best Management Practices (BMPs) can be utilized as part of the implementation strategy to help reduce sediment loading to Nutrioso Creek.

Cattle grazing in the riparian corridor could be confined to only the dormant winter months, which will allow for the emergent plants in the spring to grow and take hold. This will also allow for a greater diversity of plant communities in the riparian corridor will help establish more protective cover for the erosive soils, and act as stream energy dissipaters during higher flows. The cattle's hoof action will also act to compact soils and add in nutrients during their dormant months grazing period which is recommended according to the Bureau of Land Management. Also, the cattle will feed on the mature old growth allowing room in the spring for the new growth to occur and compete for resources.(7, 10, 11) The USFS recommends that grazing allow for adequate stubble height of the vegetation going into the spring growing season.(35)

The Apache-Sitgreaves National Forest has already implemented, or plans to implement, a variety of BMPs on lands under their jurisdiction including: (35)

1. Reduced timber cutting
2. 40 miles of roads were closed as an erosional control measure in 1999
3. Apache-Sitgreaves National Forest Grazing Allotment revisions include:
    a) Adjusted cattle entry times and densities
    b) Since 1995 they have had a 66% reduction in cattle numbers on the Alpine district
    c) A goal to balance the permitted numbers with the allowable use by 2005 in all Apache-Sitgreaves National Forest Grazing Allotments

OTHER POSSIBLE PROJECTS

The areas where historic overgrazing occurred may have the riparian corridor fenced off on private land to keep out cattle and elk during critical growing periods.

Stream grade stabilization structures (SGSS) can be installed to help protect the at risk banks during high critical flow events. SGSS can also be used to help dissipate stream velocities and thus dissipate stream energy and erosional forces during high flows.(31)

Stream restoration projects could be undertaken to speed up the development of an in-channel flood plain, increase sinuosity, etc. While these projects may create a more immediate impact on improving water quality during critical flow, they are more costly and severe to implement. In this situation a more natural approach is advisable for first consideration.(29, 31)

Off channel water wells and wildlife drinkers would allow for more water to remain in the stream itself and allow for the riparian corridor to be fenced off without water-gaps for wildlife and cattle to access the stream for drinking water purposes. This would also allow for irrigation of the revegetation projects along the stream corridor.

The riparian corridor could be revegetated with willow plantings and grass seeds using a Critical Area Planting (CAP) method as outlined by the Natural Resources Conservation Service (NRCS) as a guideline. These plantings could be supplemented with sprinkler irrigated waters until they take hold on the established banks and stream course. The plantings on the upland areas beyond the stream corridor would be sprinkler irrigated until the root systems are established enough to reach the moisture in the soils. These plantings will help protect the erosive soils and act to dissipate stream energy during critical flow.(31)

Sprinkler irrigation systems combined with a poly pipe to line the irrigation ditch would increase irrigation efficiencies and allow for more water to stay in the stream and thus increase the streamflow year round. Combined with other projects and aspects of implementation these tools allow for effective revegetation and removal of cattle and wildlife from the stream course for the majority of the year by creating more forage in the managed rangeland and an alternative water source created from the groundwater wells.

Rabbitbrush eradication projects have been undertaken on some properties. By removing the Rabbitbrush and replacing it with grass seeding more grass per acre is created for cattle consumption, reducing their reliance on the riparian vegetation of the stream corridor and allowing for their removal from the riparian corridor with the use of fences and range management plans. From a watershed standpoint the removal of Rabbitbrush and reintroduction of grasses improves species diversity and composition. Also, the grasses provide a more stable root mass than the Rabbitbrush –thus increasing the soil stability of the rangelands and decreasing the amount of sediment contributed from sheet flow and wind erosion over these rangelands.[31]

MONITORING PLAN

ADEQ staff will continue to monitor turbidity, TSS, flow, and stream morphology over the next several years during varied flow stages. The Little Colorado River watershed is scheduled for more intensive ambient monitoring in 2001 as a part of the Fixed Station Network (FSN) rotating watershed approach.

Macroinvertebrate sampling will be undertaken in the Spring/Summer of 2000 in order to obtain the necessary information to calculate an Index of Biological Integrity (IBI) score. This information coupled with a forthcoming Arizona Game and Fish Department (AGFD) study of the aquatic health of the stream and the BLM Proper Functioning Condition (PFC) score will allow for a more direct measure of the health of the Nutrioso Creek ecological system.[8, 9] This data will augment the turbidity and TSS data, as it is a more direct measure of stream health for the aquatic and wildlife cold water designated use currently being impaired. This data will allow for the reevaluation of the strategies and milestones undertaken as part of an implementation plan.

Bank Erosion Pins were installed into a vertical bank (approximately 15 ft in height) at a site in the middle of the impaired portion of the stream. These bank erosion pins will be monitored over time to see if the channel morphology stabilizes and starts to create a stable point bar and cutbank relationship with a flood plain as opposed to the present advancing vertical faces.[17]

Various other data has been obtained that will allow ADEQ to monitor water quality and physical integrity of Nutrioso Creek. These include:

- Historic photo monitoring sites are present on some sites on Nutrioso Creek, which can be utilized for future comparisons.

- Stream channel cross sections were collected at certain sites and will be used for future comparisons to see how the channel morphology has changed.

- Bank Erosion Hazard Index (BEHI) data can be used to make comparisons as to how stable the banks are along the stream.

- Permanent follow-up monitoring sites will be selected depending upon the location of future implementation projects and sampled to establish simple trend analysis.

Potential volunteer monitoring could be a source of additional data if the private landowners were provided the correct equipment and training.

TIME LINE

The Nutrioso Creek TMDL will use a Phased Approach to TMDL implementation. Watershed projects will be started incrementally as they are funded. The time frame for implementation is estimated to be 5 years. Therefore the timeframe estimated for Nutrioso Creek to meet the turbidity standard during critical flows is approximately 5 - 20 years, depending upon the amount and the duration of flow events in Nutrioso Creek. The US EPA recognizes that sediment TMDLs with primarily non-point sources of pollution can be difficult to manage, and that these problems are often generated over multiple generations and may require as long to correct.[32]

IMPLEMENTATION ACTIONS	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Public outreach & involvement	X	X	X	X	X
Establish Milestones	X				
Secure project funding	X	X	X	X	X
Best Management Practices	X	X	X	X	X
Determine BMPs effectiveness		X	X	X	X
Reevaluate Milestones and strategies					X

MILESTONES

Milestones will be used to determine if control measures and BMPs are having a positive impact on reducing turbidity and the erosional forces present in Nutrioso Creek. A Bank Erosion Hazard Index (BEHI) score was determined for sections of Nutrioso Creek. This BEHI information will be used to help locate and rank areas of primary concern for implementation projects. Various measures will be utilized as milestones to measure success of projects and BMPs, such as an overall percent reduction in exposed banks, an increased amount of willows in the stream course, more stable BEHI scores, more stable channel geometry, lowered stream velocities, and lowered TSS and turbidity values. The milestones will be reevaluated periodically to determine their validity and effectiveness, as more data becomes available.

Some goals of the TMDL implementation strategies will be to:

1. Increase education and public awareness to local landowners through the public participation process and watershed group activities
2. Create milestones for each BMP and Project and reevaluate the effectiveness as necessary
3. Decrease Stream Velocities during critical flow events utilizing,
    a) Willow vegetation
    b) Stream grade stabilization structures
    c) Increase the flood plain (addition of point bars), natural creation preferred
4. Decrease sheet flow and wind erosion contributions to Nutrioso Creek
    a) Remove Rabbitbrush
    b) Increase density of grasses as land cover
    c) Promote BMPs
5. Stop downcutting of the stream channel and promote stabilization of the channel
    a) Remove cattle and wildlife from the stream channel during critical flow periods
    b) Allow cattle to graze in the dormant winter months, under a range management system
    c) Revegetation of the stream channel
    d) Allow time for stabilization of stream banks to occur
    e) Promote BMPs
    f) Use stream restoration techniques to speed up recovery of stream corridor sections

ASSURANCES

Arizona Revised Statutes do not contain specific language that allows for enforceable actions to be taken against non-point sources of pollution.(1) This Implementation plan depends solely upon the volunteer approach of private landowners, with ADEQ's assistance, securing grant money for implementation projects and BMPs. Cooperation of State and Federal Agencies and private landowners will be paramount in the implementation of this TMDL.

PUBLIC PARTICIPATION

PUBLIC PARTICIPATION IN THE TMDL PROCESS

Public participation occurred in collecting data, background information, and in developing this report. The draft TMDL was made available for a public comment period lasting 30 days and starting on June 1, 2000. Public notice of the availability of the draft document was posted in a newspaper of general circulation (*The Observer*), email notifications, phone calls, and webpage postings. The Nutrioso Creek TMDL Draft was presented to the Upper Little Colorado Watershed Group in their June 22, 2000 meeting.

WATERSHED GROUP

The Nutrioso Creek watershed Partnership was formed in November of 1998 and is officially represented at every Upper Little Colorado River watershed group meeting by Mr. James W. Crosswhite.[(13)] The Nutrioso Creek Watershed Partnership incorporates concerned private citizens, private landowners, and other interested State and Federal Agency personnel. The watershed group will provide oversight for the implementation projects and plans, and may provide additional data in the form of volunteer monitoring of the stream.

WEB SITES

ADEQ has a website at http://www.adeq.state.az.us that will provide information and links to other data relevant to this Nutrioso Creek TMDL and contact information. This TMDL should be available for download from the ADEQ website in the foreseeable future.

Another website containing information regarding Nutrioso Creek, maintained by private landowner James W. Crosswhite of the E.C. Bar Ranch, is located at http://www.ecbarranch.com and is maintained in collaboration with his current conservation and ranching projects. This website provides contact information and links for more information and questions, has photos of projects in progress, a delineation of the project areas, information regarding BMPs, grant writing, funding sources and much more. This website will be a useful tool for the watershed group in disseminating their information and projects.

LIST OF ABBREVIATIONS

ADEQ	-	Arizona Department of Environmental Quality
AGFD	-	Arizona Game and Fish Department
ALRIS	-	Arizona Land Resource Information System
ARS	-	Arizona Revised Statutes
AWPF	-	Arizona Water Protection Fund
AZ	-	Arizona
BEHI	-	Bank Erosion Hazard Index
BG	-	BackGround
BLM	-	Bureau of Land Management
BMP	-	Best Management Practices
CAP	-	Concentrated Area planting
cfs	-	Cubic Feet per Second
EPA	-	Envrionmental Protection Agency
EQIP	-	Environmental Quality Incentive Program
Ft	-	Feet
GIS	-	Geographic Informational Systems
IBI	-	Index of Biological Integrity
LA	-	Load Allocation
lbs/day	-	Pounds per Day
LR	-	Load Reduction
MDEQ	-	Montana Department of Environmental Quality
mg/L	-	Milligrams per Liter
mgd	-	Millions of Gallons per Day
ML	-	Measured Load
MOS	-	Margin Of Safety
NMED	-	New Mexico Environmental Department
NRCS	-	Natural Resources Conservation Service
NTU	-	Nephelometric Turbidity Units
PFC	-	Proper Functioning Condition
Q	-	Discharge
SIP	-	Stewardship Incentive Program
SGSS	-	Stream Grade Stabilization Structures
Std	-	Standard
TL	-	Total Load
TLC	-	Target Load Capacity
TMDL	-	Total Maximum Daily Load
TSS	-	Total Suspended Solids
Turb	-	Turbidity
US	-	United States
USFS	-	United States Forest Service
USGS	-	United States Geological Survey
WLA	-	Waste Load Allocation

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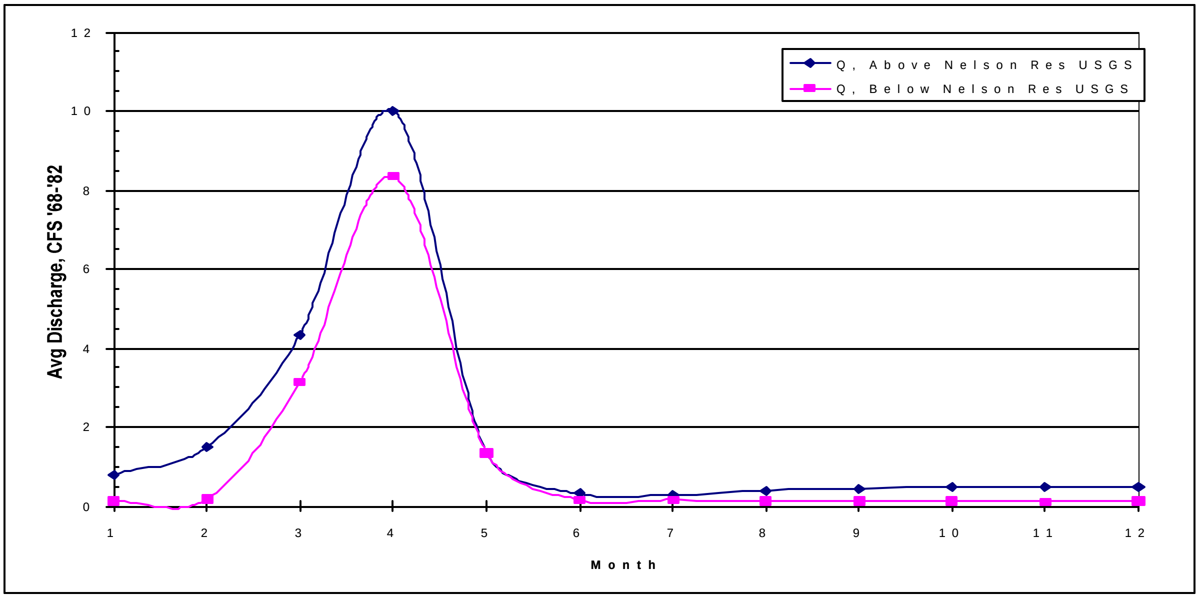
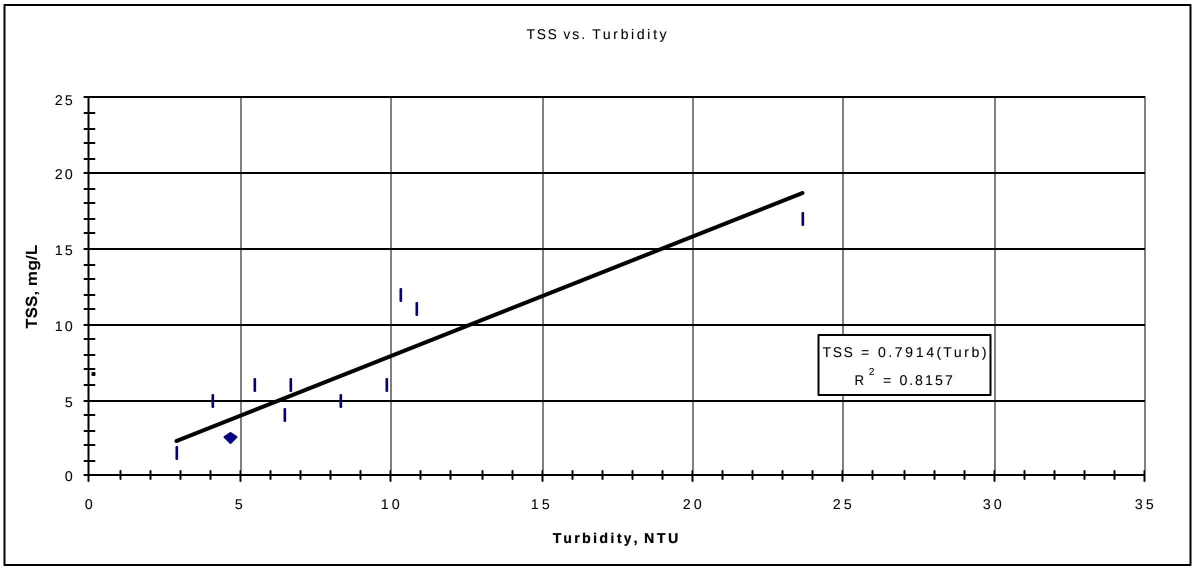
APPENDIX

GRAPH 1:
AVERAGE MONTHLY STREAM DISCHARGE AT USGS GAUGE STATIONS



GRAPH 2:
TSS VS. TURBIDITY FOR NUTRIOSO CREEK



APPENDIX

GRAPH 3

TSS AND TURBIDITY VS. DISCHARGE